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Spatial Scaling Relationship for Surface Heat Fluxes Over Mountainous Terrain

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Abstract

Surface heat fluxes as computed by Soil-Vegetation-Atmosphere-Transport-Schemes (SVAT) coupled to atmospheric models assume a flat or uniformly sloping terrain. This assumption may impose serious errors in surface flux calculations due to heterogeneous topography, and these errors depend on the geographic scale on which the calculation is performed. We calculated how fluxes computed by a SVAT vary with scale for a synthetic smooth saddle surface and a mountainous region in the Sierra. Both surfaces have a latitude of 40^{o}N, with a sinsoidally specified diurnal temperature and with computed incident radiation corresponding to June 8. The Sierra study consists of three different length to area ratio cases: (1) length = 0.1 km and area = 1.0 km^2, (2) length = 1.0 km and area = 10^2 km^2, and (3) length = 10 km and area = 10^4 km^2. We used a homogeneity testing and grouping technique to produce a reduced number of sub-areas with similar topographic characteristics. We computed surface fluxes for each sub-area independently using the Biosphere-Atmosphere Transfer Scheme (Dickinson et al., 1993). We compared normalized area-weighted mean daily fluxes to fluxes corresponding to a flat surface. The results indicate that for case (1) the flat surface overpredicts the Bowen ratio by 20%, for case (2) the flat surface overpredicts by 5%, and for case (3) the flat surface value is nearly equivalent to the detailed topographically computed Bowen ratio. Case (2) was recomputed at three latitudes: (a) 70 ^{o}N, (b) 40^{o}N, and (c) 10^{o}N, yielding overpredictions for the flat surface value of 3%, 5%, and 12%, respectively. These results indicate that the sensivity of surface flux response varies over a range of scales, is a negative exponential function of the ratio of the total area to the length scale, and a positive exponential function of latitude.

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